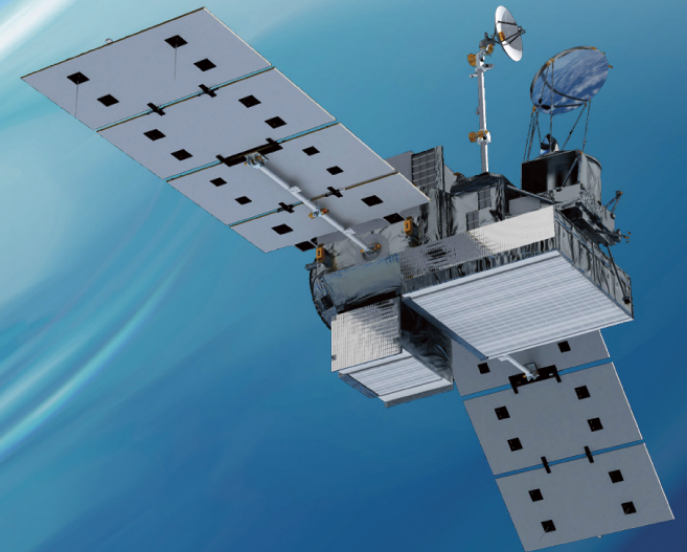


DPR Sensor Status Including Experimental Results

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Japan Aerospace Exploration Agency



Outline



- * Operations Status of DPR
- * Scan Pattern Change Test Operations Results
 - * KaPR HS outer swath test
 - * Wide swath test
- * Summary

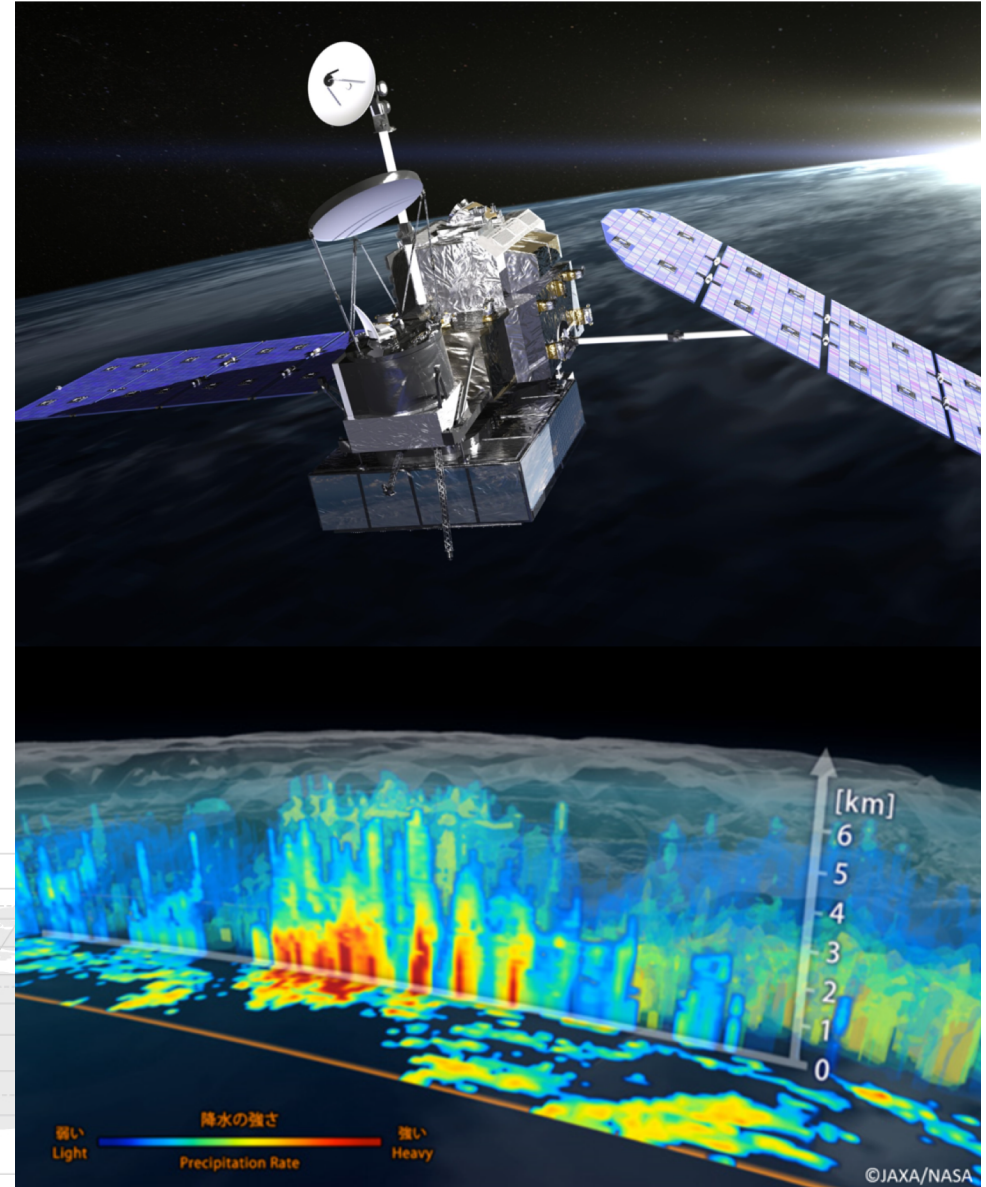


Operations Status of DPR



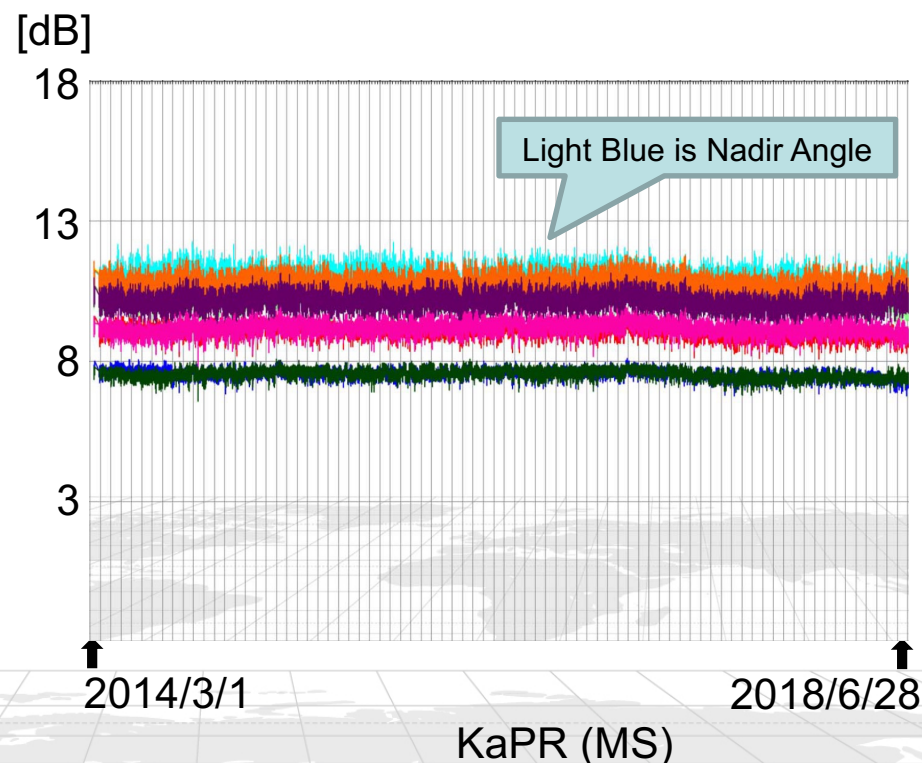
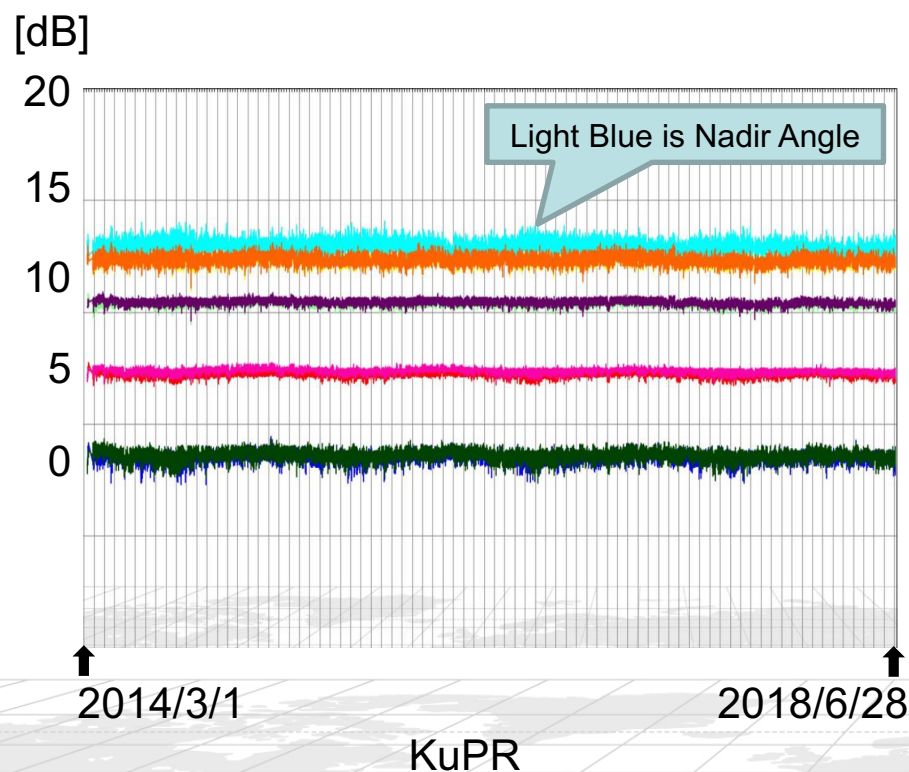
Orbital Operations

- * DPR completed its prime mission phase in May 2017 and moved to extended mission phase.
- * JAXA is continuing DPR data monitoring.
 - * HK and science telemetry (Continuously)
 - * Sea Surface Radar Cross Section (σ_0) (Continuously)
 - * Internal Calibration (Once a week)
 - * External Calibration (5 times in one campaign. 2 campaigns in a year)
 - * TX/RX Amplifier Status (2 times in a year)



Sea Surface Radar Cross Section

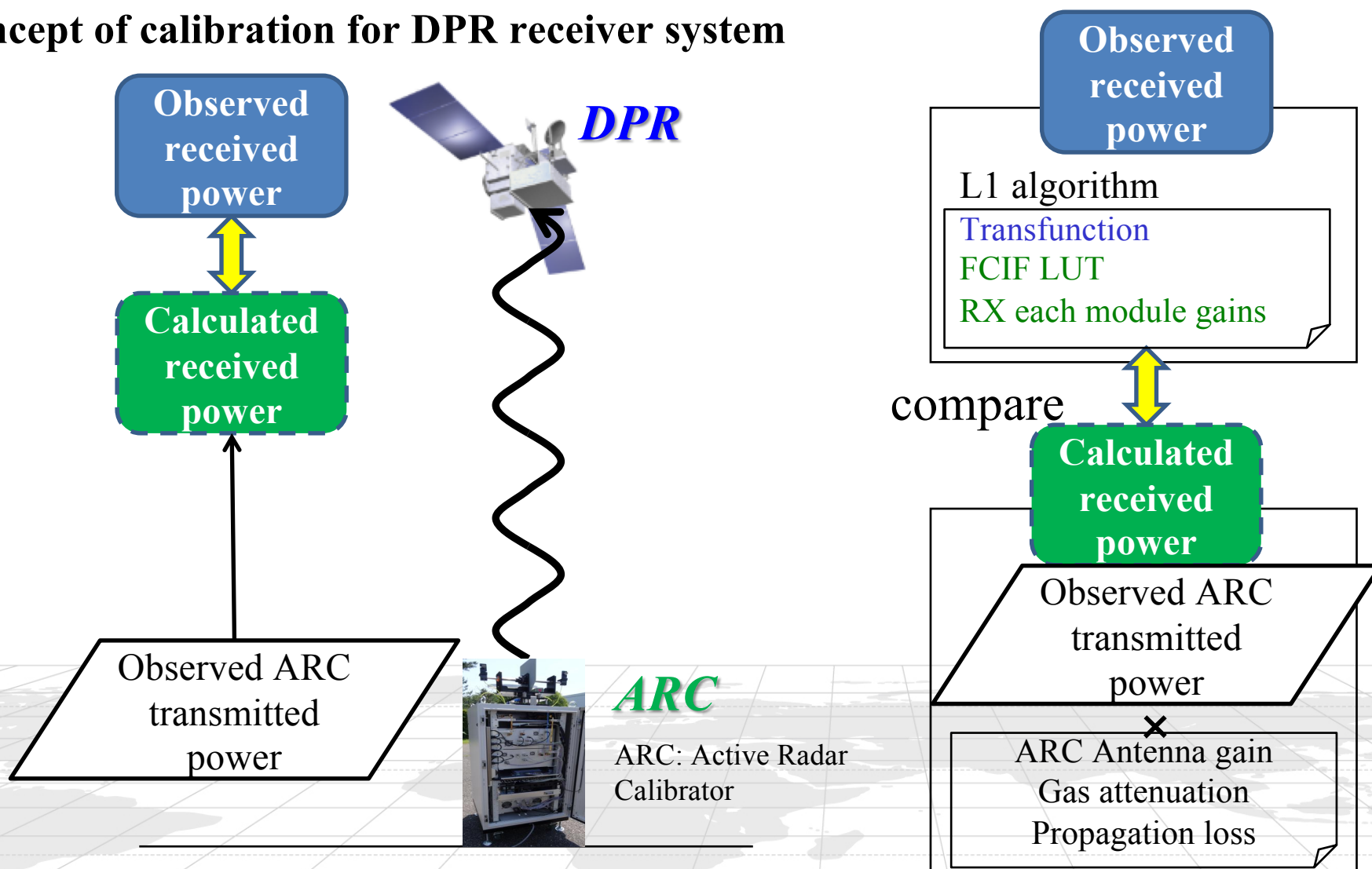
- Sea Surface Radar Cross Section trend is monitored to confirm over all radar performance.



- Both KuPR and KaPR Sea Surface Radar Cross Section trend are almost stable. There is no degradation of KuPR and KaPR performance.

Concept of External Calibration

Concept of calibration for DPR receiver system



In case of calibration for DPR transmit system, DPR transmit power is evaluated using received power of ARC.

External Calibration

Active Radar Calibrator (ARC)

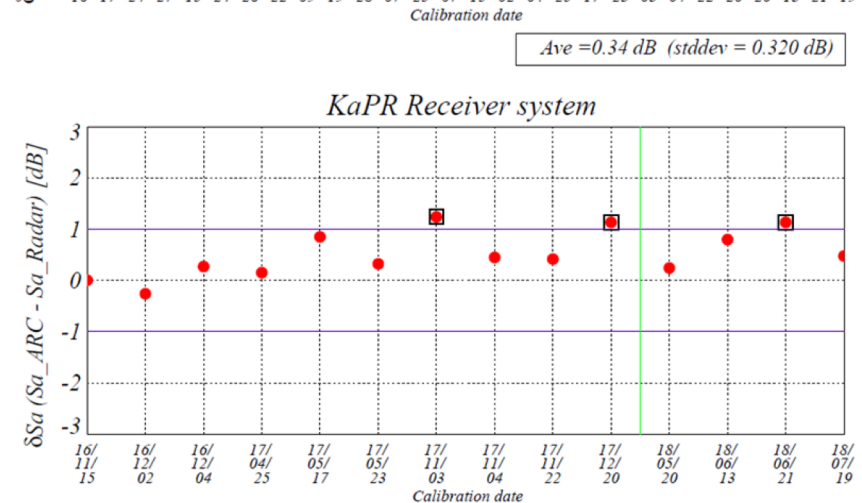
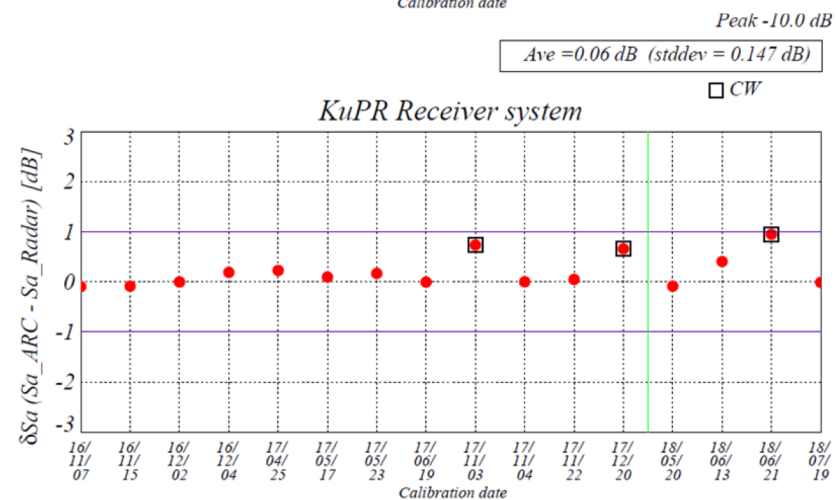
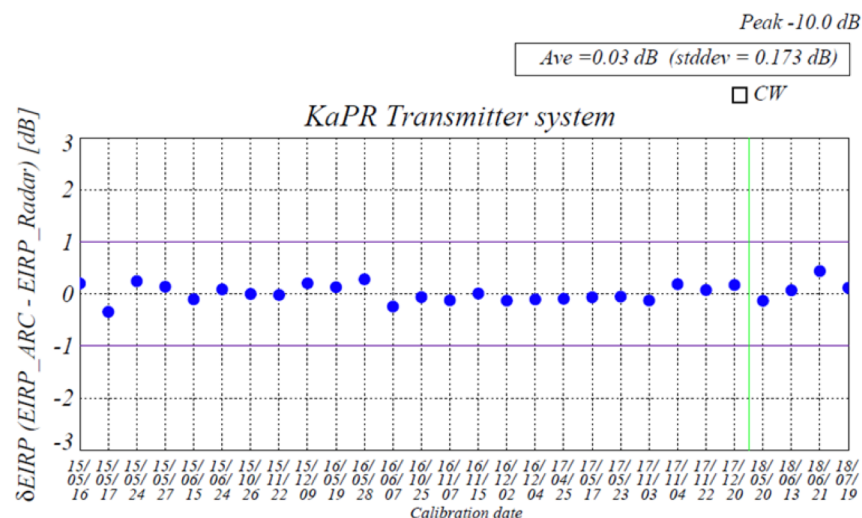
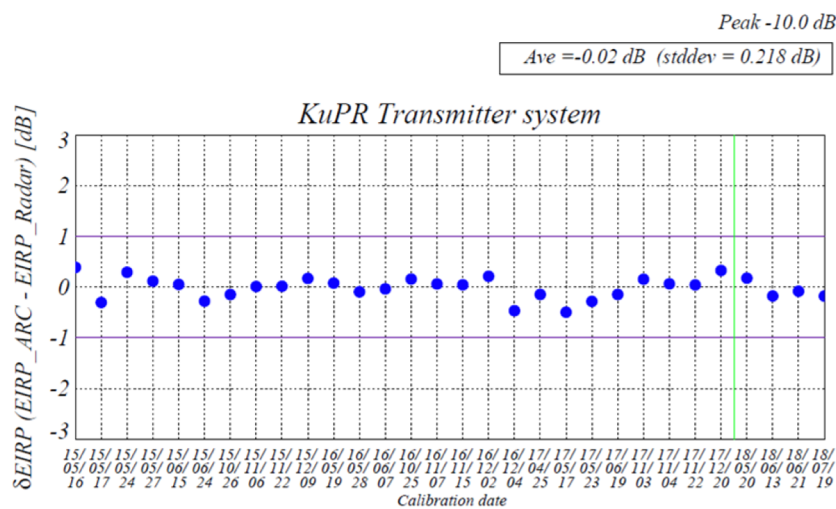


The situation of external calibration



Absolute TX/RX power (External Calibration)

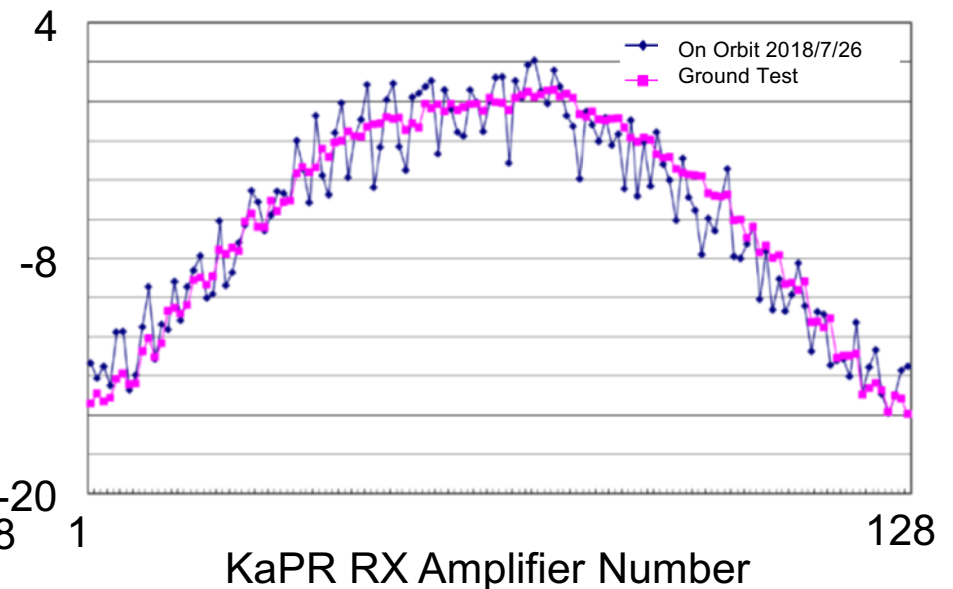
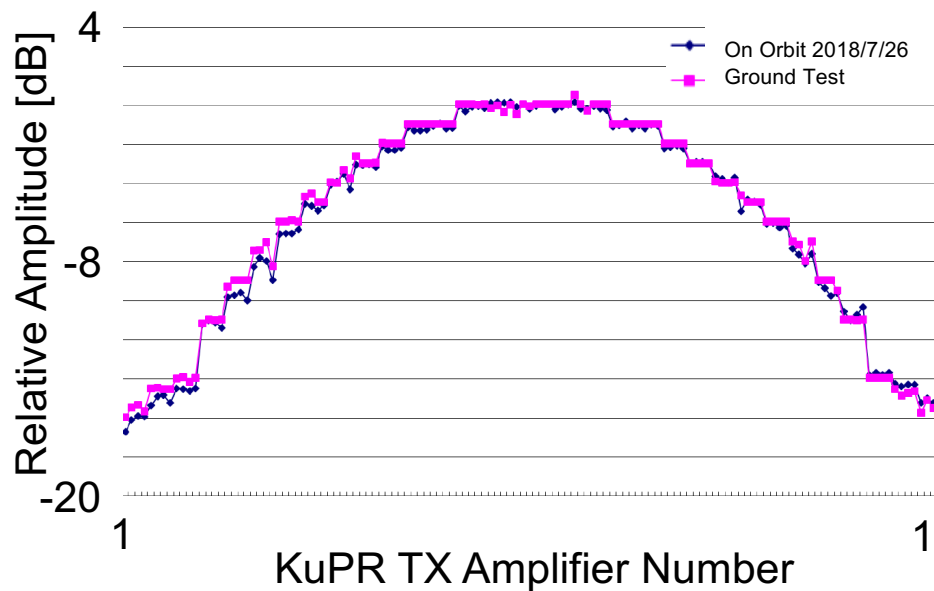
- KuPR and KaPR absolute TX/RX power should be within ± 1 dB.



- Estimated absolute TX/RX power are within ± 1 dB.

TX/RX Amplifier Status

- KuPR and KaPR consists of 128 TX/RX modules, TX/RX Amplifier Status were monitored to confirm that TX/RX amplifier keep their performances.



- Relative Amplitudes of KuPR and KaPR TX/RX amplifiers are almost same as ground test results. There is no degradation of KuPR and KaPR TX/RX amplifiers performance.

DPR data monitoring results show that there is no degradation of DPR function and performance from Launch till now.

Scan Pattern Change Test Operations Results



Overview of the Test Operations



- * 2 kinds of scan pattern change test operation has been conducted.

- * KaPR HS outer swath test

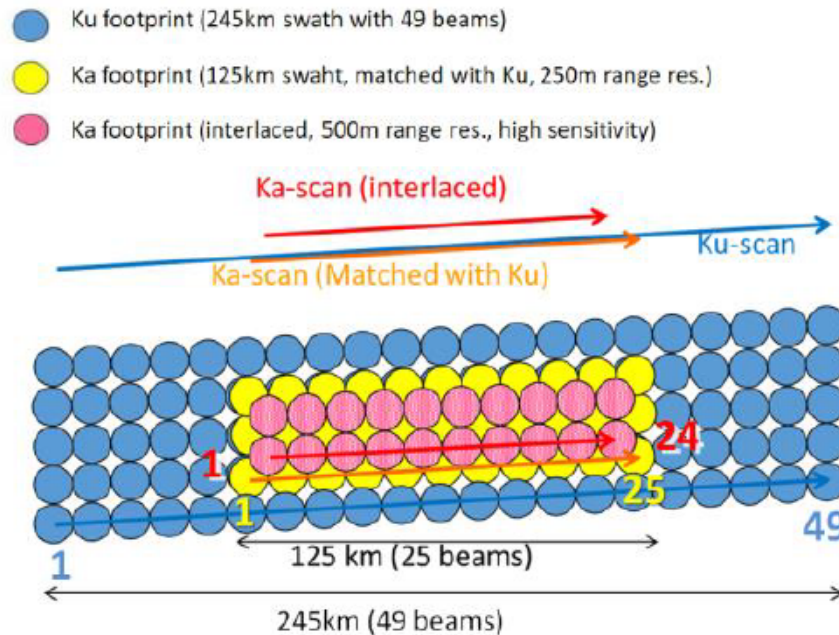
- * September 26th -29th in 2017, February 20th -22nd in 2018
 - * To confirm feasibility of KaPR HS outer swath observation for DPR.

- * Wide swath test

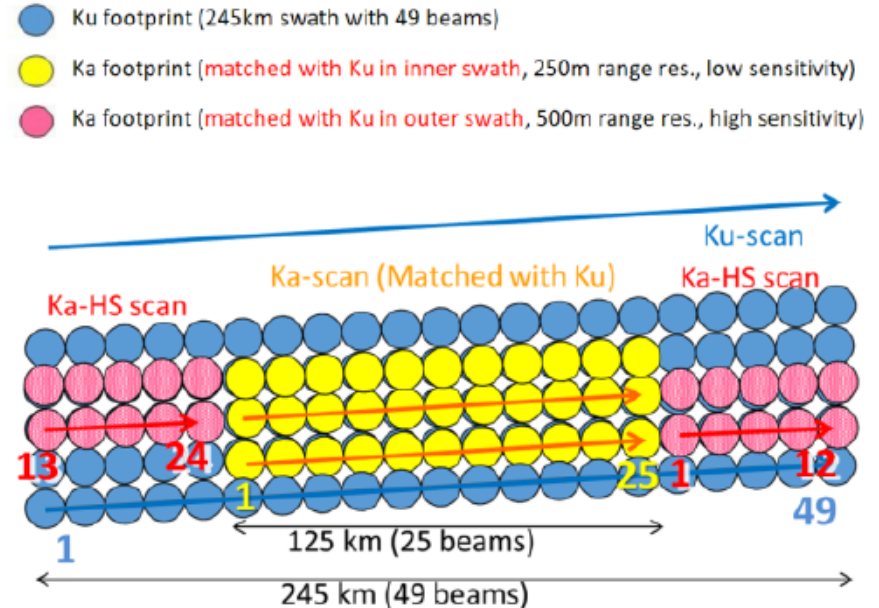
- * September 26th -29th in 2017
 - * To confirm feasibility of wider swath observation for future precipitation radar.

KaPR HS outer swath test

before



after



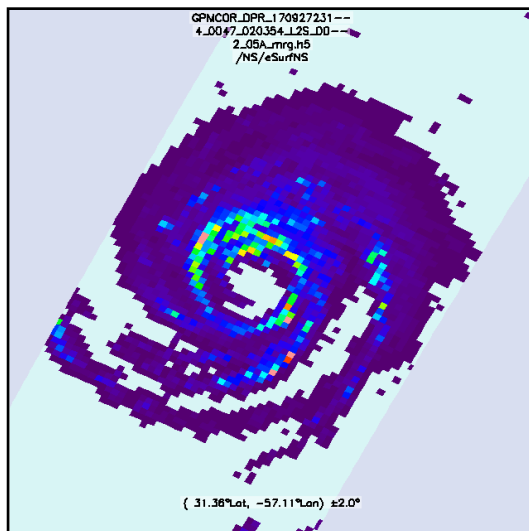
- KaPR-HS's scan pattern was changed.
→ Dual-frequency technique can be applied in a full swath.

Experiments results (Horizontal)

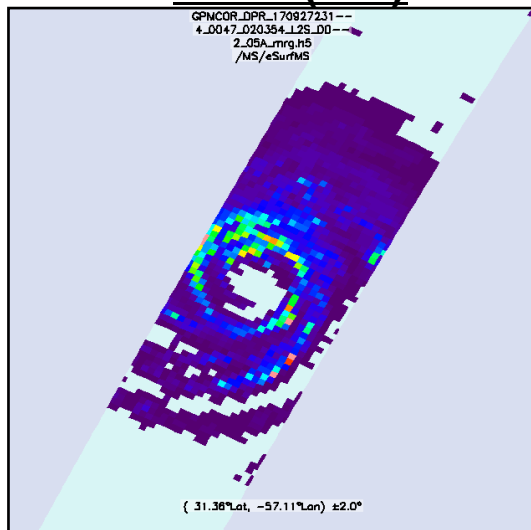
DPR L2: precipRateESurface

The current L2 algorithm is still in development phase.

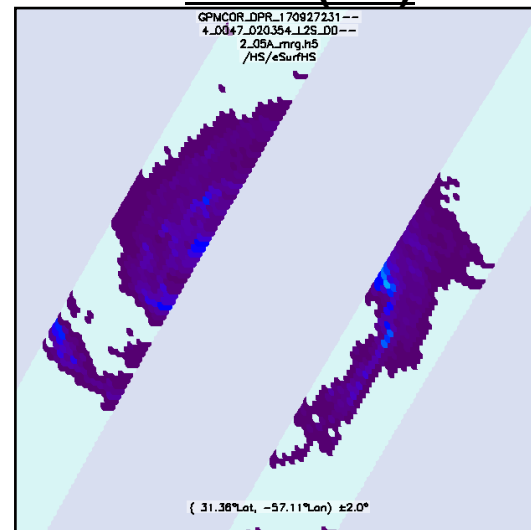
KuPR



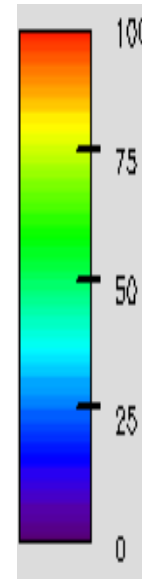
KaPR(MS)



KaPR(HS)



[mm/h]

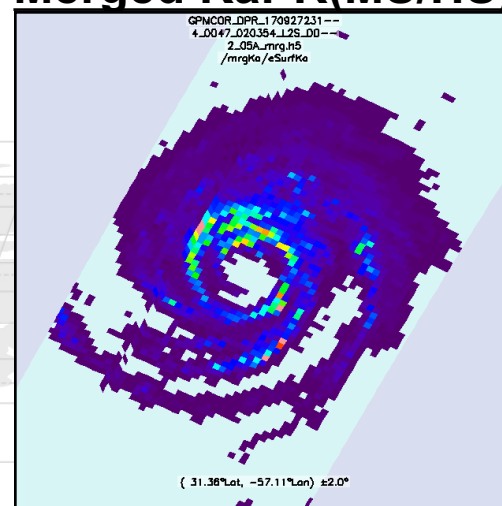


Sep 27th 2017
Hurricane LEE



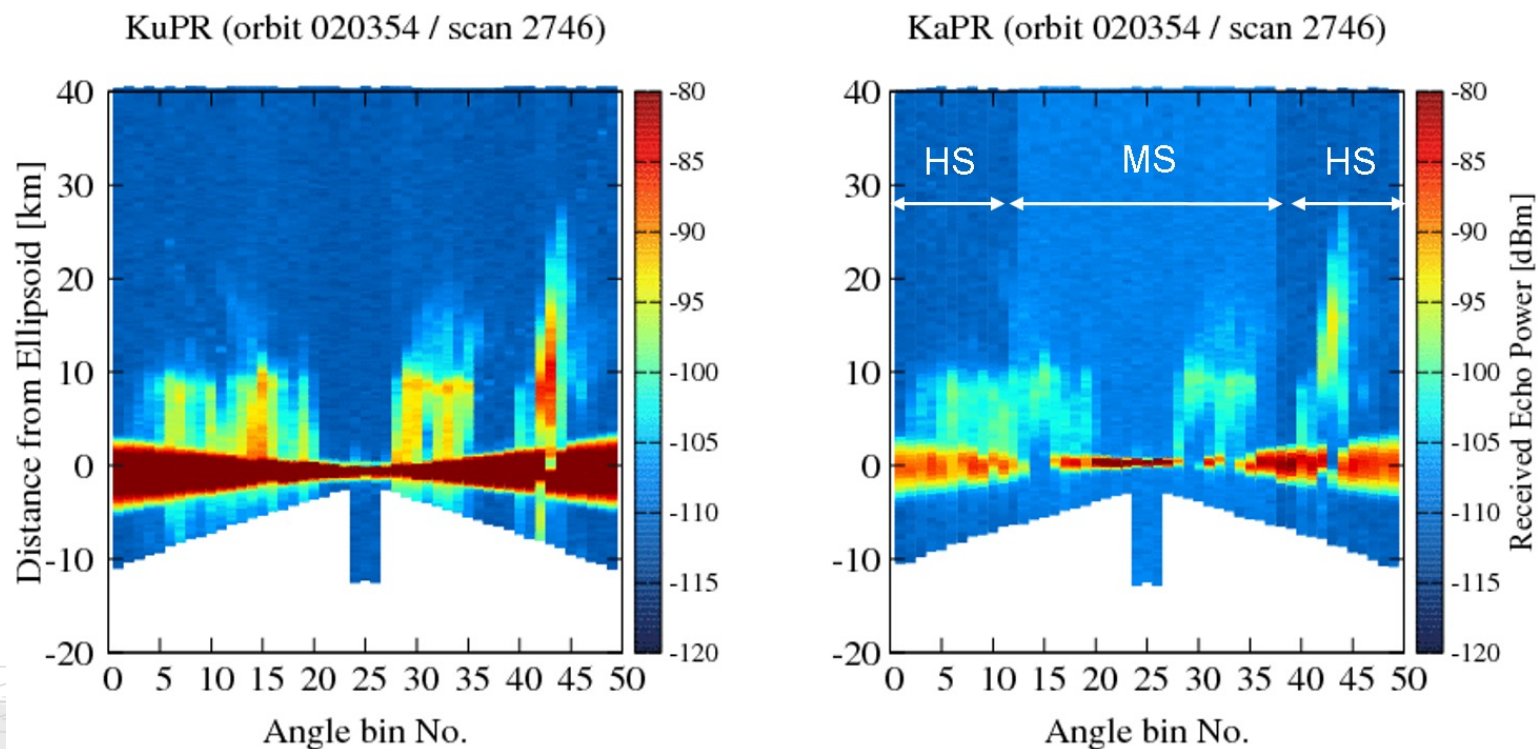
Merged KaPR is almost same
as KuPR observation.

Merged KaPR(MS/HS)



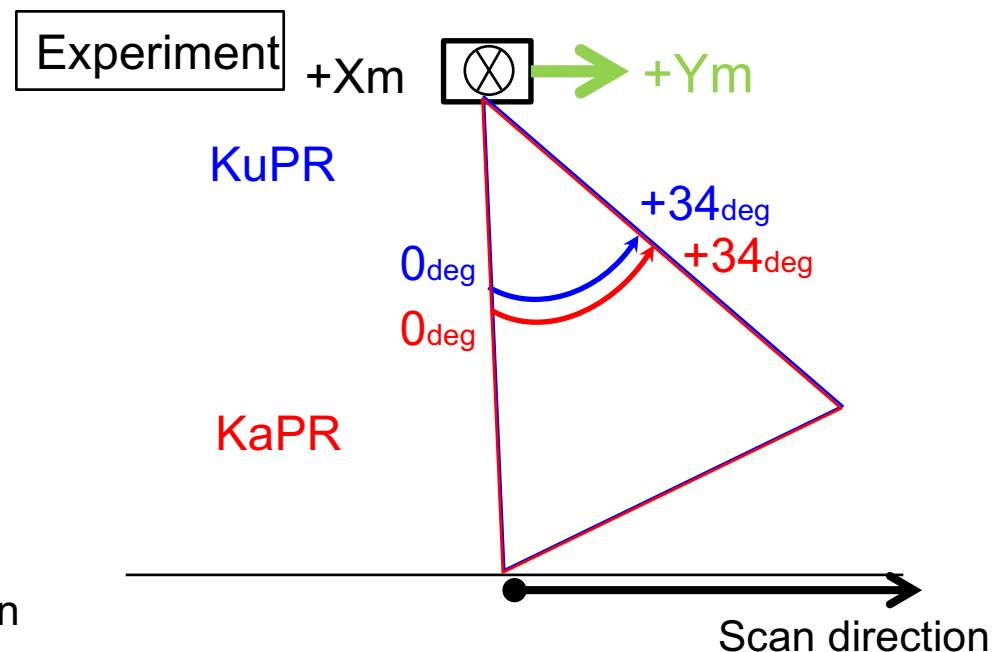
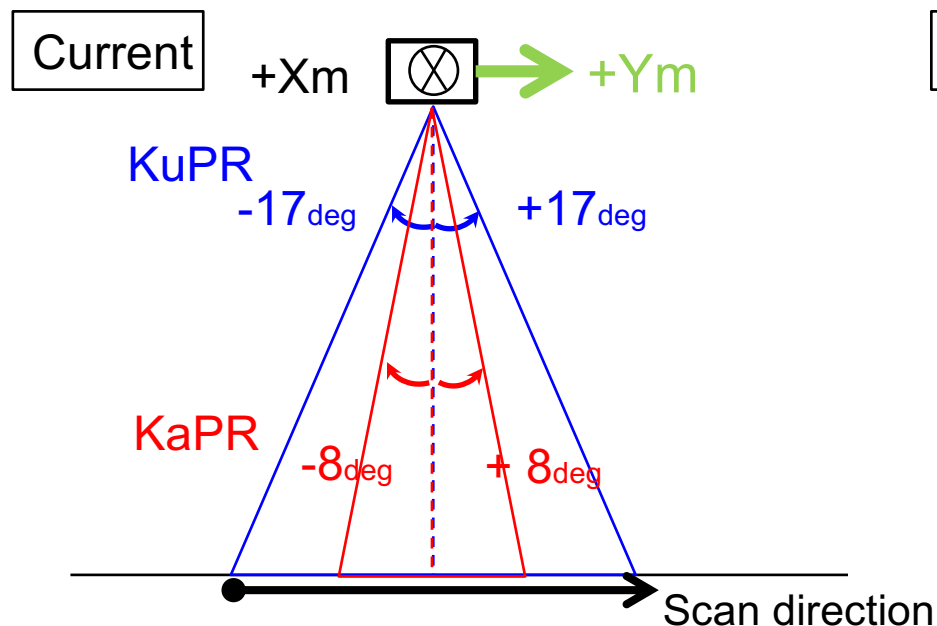
Experiments results (Vertical)

- * JAXA confirmed DPR is working as expected during KaPR HS outer swath test.



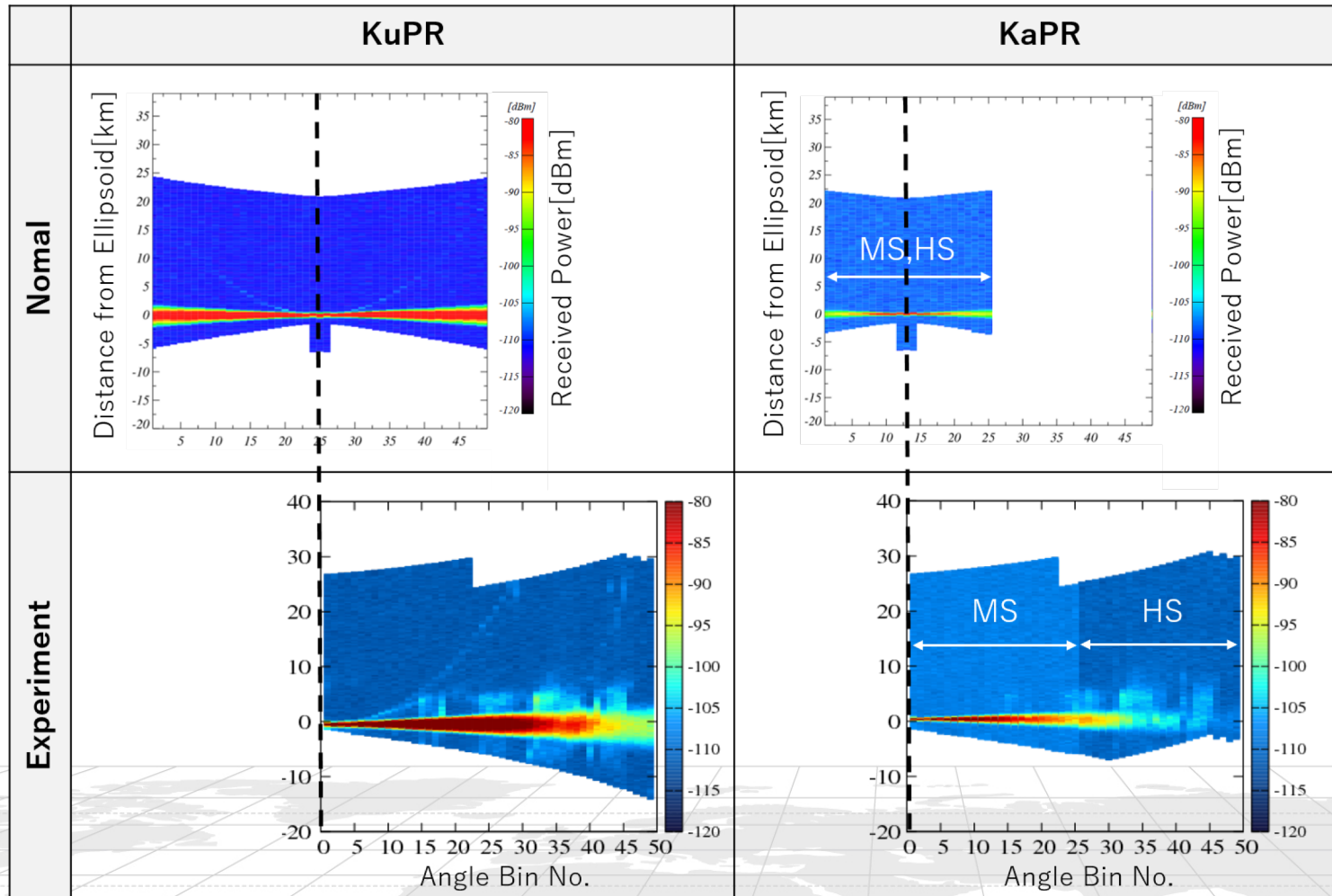
- * KaPR HS Outer Swath Observation Start on May 21st 2018.

Wide swath experiment (KuPR and KaPR)



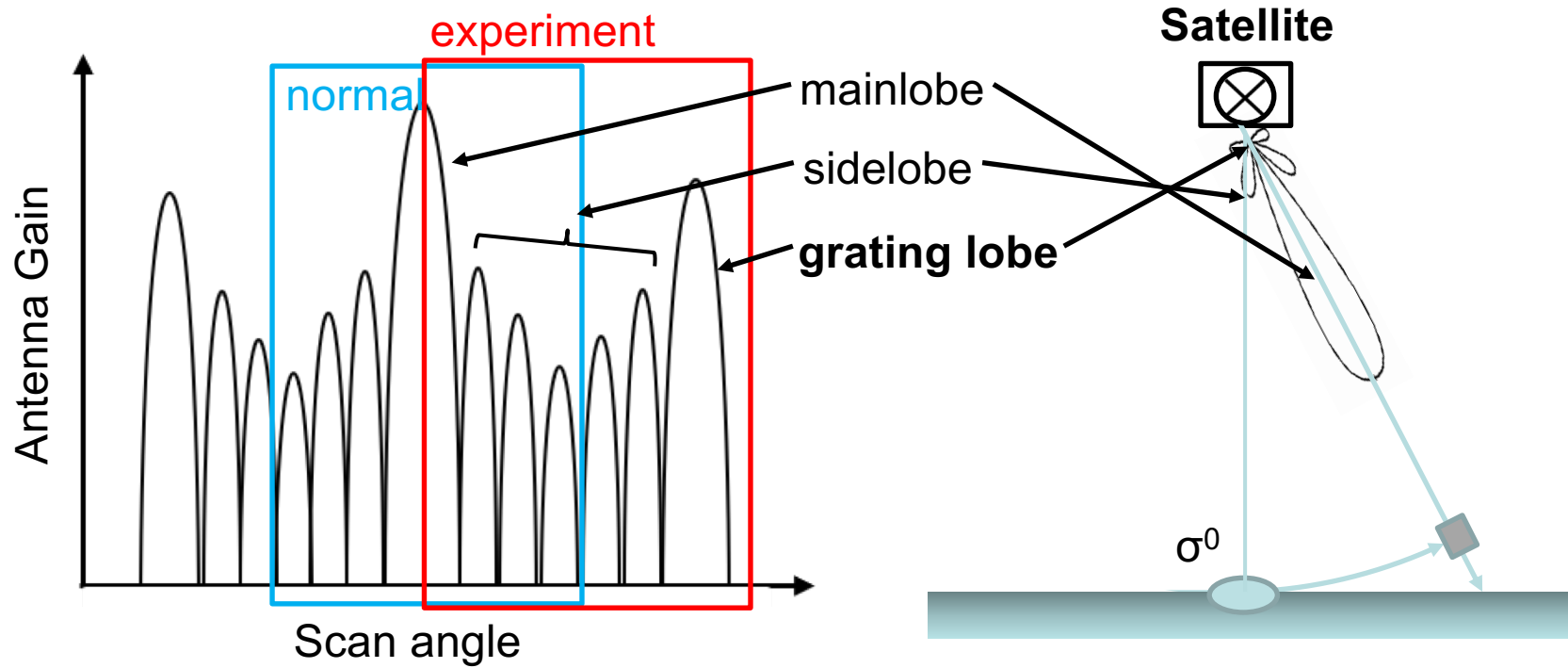
- Scan patterns were changed both KuPR and KaPR.
 → Toward a future radar development.
 (These scan patterns will NOT be applied in DPR nominal observation.)

Cross Section of the Scan



* The scan was successfully changed and captured precipitation echo in the wider angle.

Radar Clutter Issues

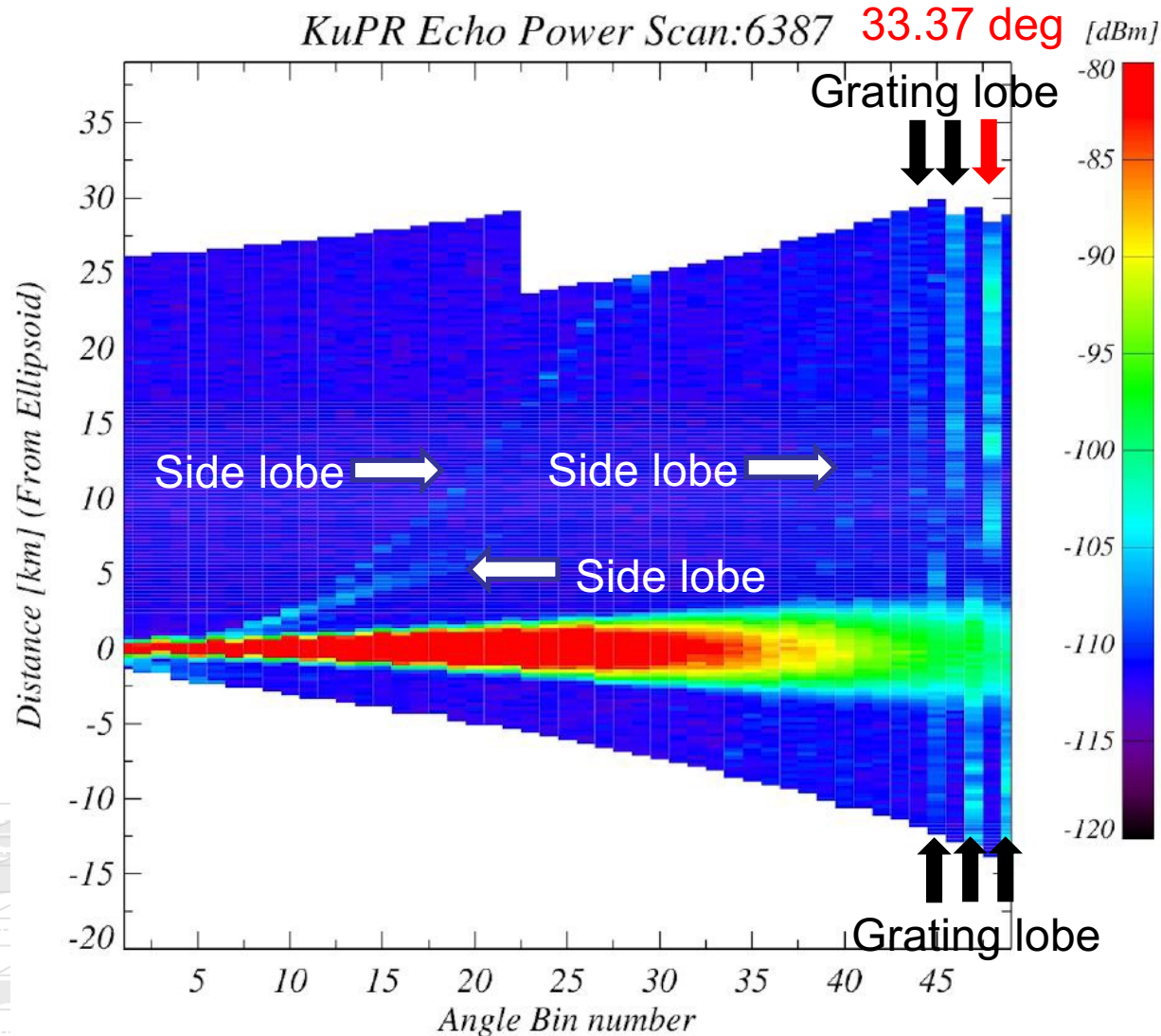


* Spaceborne radar receives both faint rain echoes and strong surface echoes simultaneously

* Surface clutter interference through antenna sidelobes occurs when sidelobe levels are not low. Sidelobe reducing method is already developed and applied to the DPR data processing. (Kubota et al. 2016)

* In addition to the sidelobe clutter, grating lobe (2nd highest directivity) issue emerged due to the wide swath observation, by using alley antenna.

Experiment Results



* There are side lobe clutters and grating lobe in some scans.
Obvious grating lobe effects occurs at 33.37 deg.

Grating Lobe Criteria

- * Grating lobe will not occur when scan angle θ meet criteria below, when using alley antenna

$$|\theta| \leq \sin^{-1} \left(\frac{\lambda}{d_e} - 1 \right)$$

λ : Wave Length

d_e : Interval of Antenna Elements

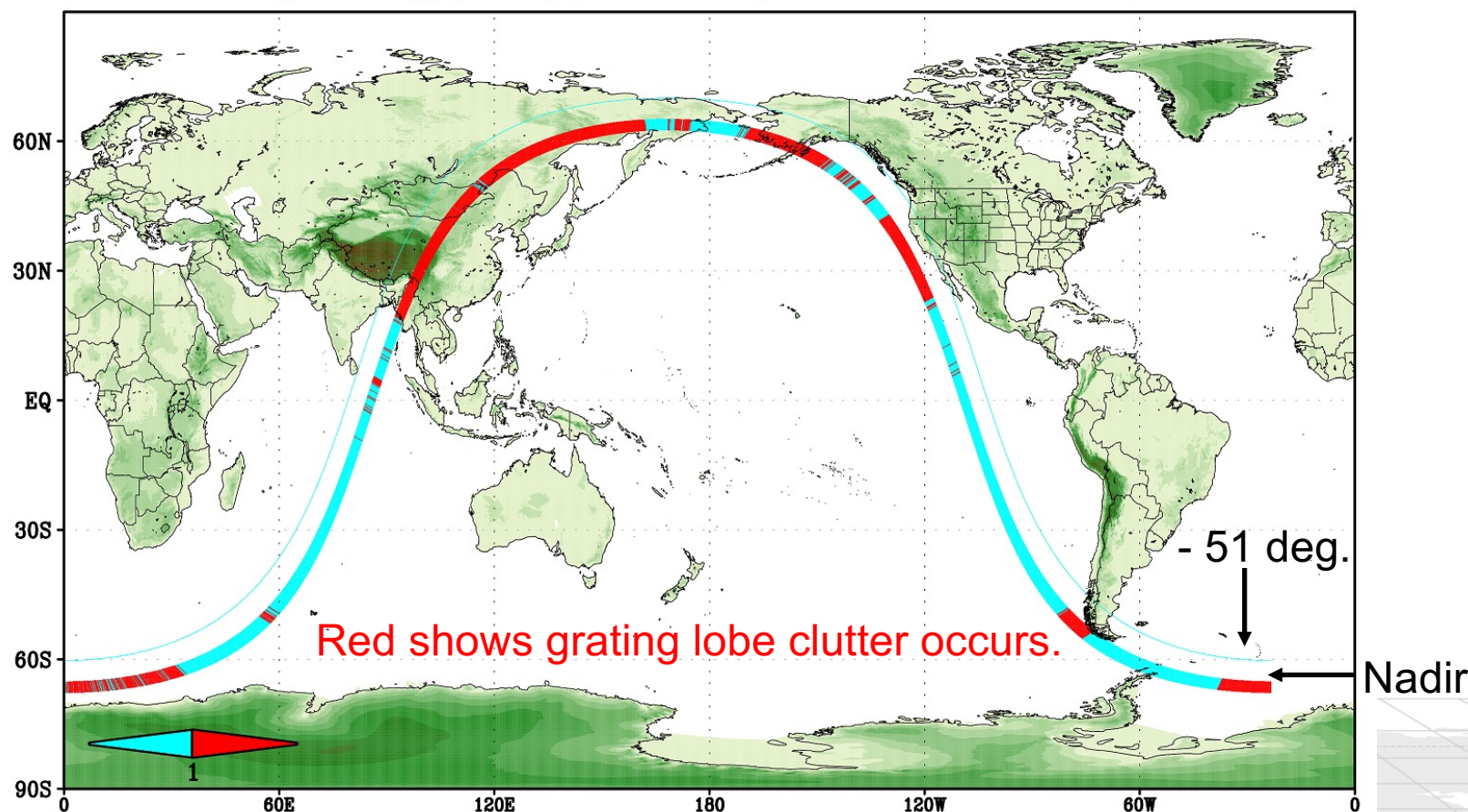
- * When θ is over this criteria, grating lobe occurs at $-\theta'$ direction.

$$\sin \theta' = \frac{\lambda}{d_e} - \sin \theta$$

- * For example, when grating lobe cratter occur at 33.37 deg, glating lobe direction is – 51.16 deg.

Experiment Results

grating_lobe_clutter (orbit No.020332)



* Most of grating lobe clutter at 33.37 deg. are seen where – 51 deg. angle is over land and rough sea surface such as “Screaming Sixties”.

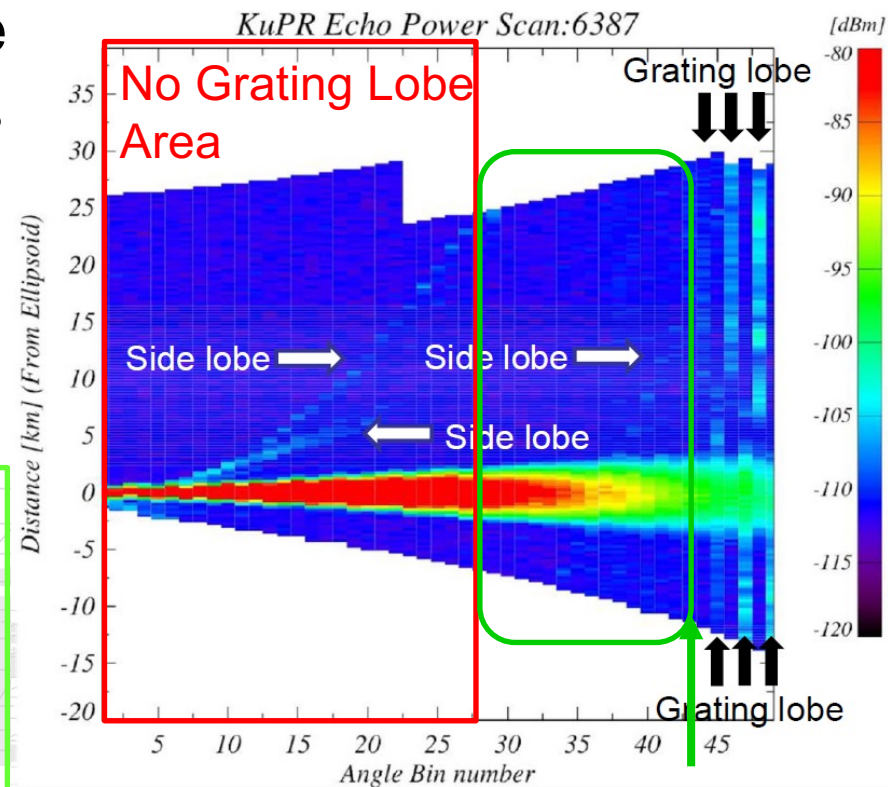
This means grating lobe clutter occurs when surface clutter of direction of grating lobe is high.

Experiment Results

* Grating lobe will not occur when scan angle θ is smaller than criteria. Calculated criteria for KuPR is ± 19.1 degree. Over this scan angle, grating lobe clutter might be observed.

* However even in possible grating lobe area, there is no obvious grating lobe clutter until around 30 deg (~ 215 km).

* There is possibility that the future precipitation radar can expand swath. ($\sim \pm 215$ km)



Summary



- * JAXA is continuing DPR data monitoring and confirmed that **DPR function and performance are kept on orbit in the extended mission phase.**
- * KaPR HS Outer Swath scan pattern change test operation has been conducted. JAXA confirmed DPR is working as expected during KaPR HS outer swath test. **KaPR HS Outer Swath Observation Start on May 21ST 2018.**
- * Wide swath experiment were conducted toward a future radar development. There are obvious grating lobe clutters in some scans. However even in possible grating lobe area, there is no obvious grating lobe clutter until around 30 deg (~ 215 km). **There is possibility that the future precipitation radar can expand swath.**